

Experimental and Research Station,

Nursery & Market Garden Industries'

- - Development Society, Limited, - -

Turner's Hill, Cheshunt, Herts.

Fifth Annual Report,
1919.

THE CHESHUNT PRESS, LIMITED.

1920.

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Experimental and Research Station.

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RESEARCH ASSISTANT FOR SOIL STERILISATION.

* MRS. D. J. MATTHEWS, M.Sc. (Vict.).

Office Assistant—HELEN MARCHANT.

Laboratory Assistant—DOROTHY M. CROFT.

GLASSHOUSE WORKING STAFF.

Foreman A. A. Richards.

Cucumber Grower..... J. H. Smith.

Tomato Grower..... A. E. Judd.

Gardener A. J. Grundy.

* Working for the present at the Rothamsted Experimental Station.

TOMATO

HOUSES

SERIES L TO T
SERIES K
SERIES J
SERIES H
SERIES G

P	R	S	T
O	N	M	L
2	4	6	8
1	3	5	7
2	4	6	8
1	3	5	7
3	4		
2	1		
3	4		
2	1		

100 FEET



100 FEET

CUCUMBER

SERIES X, SERIES D, SERIES E, SERIES F

5	6	7	8	Corridor
4	3	2	1	
5	6	7	8	
4	3	2	1	
5	6	7	8	
4	3	2	1	Corridor
10	11	12	13	
9	8	7	6	
7	8	3	4	
6	5	2	1	

Corridor

Botanical Laboratory

Chemical Laboratory

Office

Dark Room
Laboratory

SERIES A & B

B.3.	B.4.	A.3.	A.4.
B.2.	B.1.	A.2.	A.1.

78 FEET

ISOLATION HOUSE

Stokehole and Boiler

Garden Border

Stokehole and Boilers

Water Tower

Packing and Store Shed

26 FEET
Roadway

Roadway

Diagram to show arrangement of experimental plots



1919

General Report.

THE Nursery and Market Garden Industries' Development Society continues to make steady progress in many directions. During the last year 14 Shareholders were enrolled, all of whom became Annual Subscribers to the Society; there are now 134 of the former and 126 of the latter. It is a pleasure to record that increased Annual Subscriptions have been promised by many growers for the next five years in order to meet the extra expenditure involved by the appointment of an Entomologist (Mr. L. Lloyd, M.Sc.) and a Mycologist (Mr. W. F. Bewley, M.Sc.) during the Year. Both these gentlemen are now on the permanent staff of the Station, and the arrangements made as to the division of the work of the Station are proving very satisfactory. Mr. Lloyd has investigated the Caterpillar trouble in Tomatoes, and is now engaged in a similar investigation on the Greenhouse White Fly. Mr. Bewley has done work on the seedling diseases of Tomatoes and other matters and during 1920 will devote his energies in the main to Sleepy Disease of Tomatoes. Mr. A. B. Lister who has hitherto been responsible for the whole work, is now in charge of the experimental work in the Glass-houses both at the Station and outside, the advisory and secretarial work, and the general management of the Society and of the Lea Valley Growers' Association.

The Station's foreman returned at the end of November after being absent nearly three years. During the busy part of the past season we were fortunate in securing the services of Mr. H. G. Hollington, one of the local growers, as temporary foreman, with the result that the Secretary had more time to devote to systematic advisory work.

During the year 1919 the Advisory Officer made 637 technical and scientific reports, 466 being sent to growers in the Lea Valley district, and 171 to growers in other parts of Great Britain. At the request of members, and in connection with the systematic visitation or the outbreak of diseases, the Advisory Officer visited 367 nurseries, only 39 of which were outside the Lea Valley district, to investigate and report on matters coming within the scope of the work of the Station.

The number of visits from growers (or their representatives) and other interested persons during the year amounted to 1,493.

The records of the last five years show that the appreciation of the Station—as measured by the number of enquiries made—is very dependent on the extent to which the scientific worker comes in personal contact with the practical man :—

	1915.	1916.	1917.	1918.	1919.
Visits to Nurseries ...	160	*51	*95	161	367
Enquiries at Station...	147	321	1,183	1,051	1,493
Technical Reports ...	63	151	474	509	637

* During 1916 and 1917 the Committee of Management was reluctantly compelled to reduce the visits to nurseries to a minimum owing to shortage of working staff at the Station.

The experimental work has, to a large extent, been a continuation of that undertaken in the previous year. New features have been the culture of cucumbers under *forced* and *slow* conditions; pot experiments with tomatoes on the effect of the nitrogen-potash ratio on the growth of tomatoes and the incidence of Stripe Disease; pot sterilisation experiments with tomatoes in an imported soil; a new series of manurial experiments with cucumbers; an investigation of the comparative effect in cucumber culture of stacked and newly-dug turf; the introduction of an unmanured plot in the manurial trials with tomatoes; and an extended experiment in borders and in pots to ascertain the relation between the growth of tomatoes and their position in the experimental houses.

Experimental Records and Tables.

Sources of Error and Uncertainty.

Behaviour of Tomato Plants according to their position in the house.

Last year four plots of tomato plants, in opposite pairs in the middle portion of House 5, gave somewhat remarkable results, the crop result when graphically exhibited showing a more or less regular zig-zag line. A further and more extended investigation of the subject was made in the same house this year, there being two plots of the variety "Ailsa Craig" facing each other (M. and S.), and two other plots, also facing each other, of the variety "Kondine Red" (N. and R.) These four plots occupied the centre of the house as will be seen by reference to the plan on the frontispiece; this arrangement was identical with that of the previous year. In addition, however, the end portions of the house were also devoted to the experiment; at the north end there were two opposite sets of pots planted with the variety "Ailsa Craig" (L. and T.) and at the south end similar sets of "Kondine Red" (O. and P.) The distances between the rows of plants, whether in plots or in pots, were alternately 18 and 27 inches as last year; there were seven rows of plants with 24 plants in each row of the eight series. The weights of fruit per plant are given in Table I., and are represented graphically in Fig. 1. In all respects there is a marked agreement in the behaviour of the two varieties both in pots and in the ground. The regular alternating high and low yield of the results is even more pronounced than last year and is apparent in all the series. There is obviously some physiological factor acting equally on both sides of the house and affecting equally both varieties. The difference between the yields from the plants in pots and in borders is more apparent on the west side of the house than on the east side. The fact that the behaviour of the plants is similar in pots and in borders rules out the suggestion that the result is a drainage effect due to the different spacing of the various rows, for there is no possibility of the drainage from one row of pots affecting the adjoining row. It is to be noted that the differences due to this unknown cause are considerably greater than those produced in many cases by manure or by sterilisation. Also on both sides of the house there is a gradual fall of yield from the centre to the side. The factor which brings about this "place effect" clearly requires further investigations by physiological methods.

Series M. & S. Variety "Ailsa Craig" in borders.
 " N. & R. " "Kondine Red"
 " L. & T. " "Ailsa Craig" in pots.
 " O. & P. " "Kondine Red"

Fig. 1.

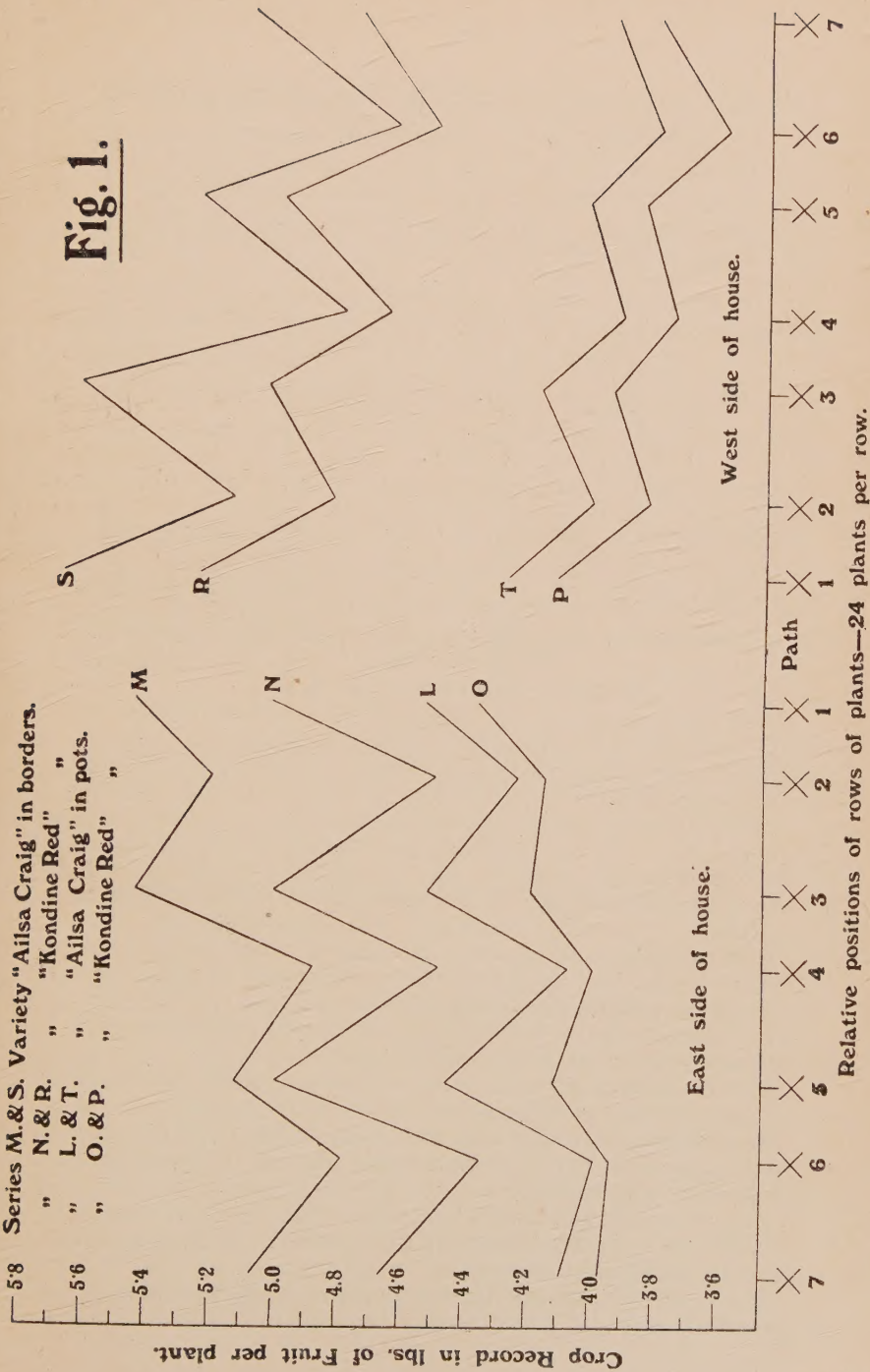


Table I.

Variety.—"Ailsa Craig."								Variety.—"Kondine Red."							
POTS.				GROUND.				POTS.				GROUND.			
Row.	Lbs.	Row.	Lbs.	Row.	Lbs.	Row.	Lbs.	Row.	Lbs.	Row.	Lbs.	Row.	Lbs.	Row.	Lbs.
L1	4.55	T1	4.29	S1	5.70	M1	5.46	O1	4.38	P1	4.13	N1	5.04	R1	5.27
2	4.25	2	4.02	2	5.17	2	5.22	2	4.16	2	3.84	2	4.51	2	4.85
3	4.53	3	4.19	3	5.63	3	5.45	3	4.20	3	3.96	3	5.02	3	5.06
4	4.08	4	3.93	4	4.82	4	4.89	4	4.00	4	3.76	4	4.49	4	4.68
5	4.46	5	4.04	5	5.28	5	5.13	5	4.12	5	3.86	5	5.00	5	5.02
6	3.99	6	3.81	6	4.66	6	4.79	6	3.94	6	3.60	6	4.35	6	4.53
7	4.09	7	3.96	7	5.13	7	5.07	7	3.97	7	3.82	7	4.66	7	4.78

Experiments in the Cultivation and Management of Tomatoes.

(a) Slow versus Forced Growth.

This experiment was continued in the Isolation House on similar lines to the previous year, except that the two types of treatment were transposed in the two halves of the house. The arrangement of the individual varieties in each section was also altered so as to place the varieties, "Comet" and "Kondine Red" in the northern portion of each half-house, where the heat was greatest due to reflection of the summer sun from the central glass partition and from the north end of the house.

This arrangement gave the conditions which the growers believe to be the best for the variety "Comet," and the crop records show that in the month of June the yield of "Comet" was the highest of the four varieties in the *forced* section and the lowest of the four in the *slow* section.

The earliest, and hence most valuable, yield is shown by the *forced* sections of all the four varieties.

This experiment is to be repeated under conditions as similar as possible to those of a trade nursery in two of our large houses next season.

The variety "Fillbasket" has done well in spite of its relatively unfavourable position; this result is in accordance with its good-yielding properties.

The result of this experiment as regards early yield is the same as in previous years but as regards total yield it was

the opposite of that of last year. For whereas in 1918 the initial superiority of the yield from the forced plants was maintained to the end, in 1919 the superior yield of the forced plants was confined to the month of June, after which the slow plants forged ahead and maintained the lead to the end of the season, finishing with a total gain of 8 per cent. as against a loss of 8 per cent. in 1918. (See Table II.). The

Table II.

Crops in lbs. per plant, on plots (18 ft. 9 in. by 9 ft. 4 in.) containing 54 plants, and occupying 1/249th of a house-acre.

VARIETY.	Series B. Forced Growth.							Series A. Slow Growth.						
	June.	July.	August	Sept.	Oct.	Nov.	Total. lbs. per plant. Tons pr acre	June.	July.	August	Sept.	Oct.	Nov.	Total. lbs. per plant. Tons pr acre
"Comet"	1.28	2.66	1.27	0.87	0.64	0.81	7.53	0.45	3.51	1.23	0.92	0.61	0.72	7.44
"Fillbasket" ...	1.20	2.85	1.71	1.01	0.73	0.88	8.38	0.66	4.33	1.47	1.20	0.68	0.98	9.32
"Ailsa Craig" ...	0.99	2.69	1.62	0.97	0.54	0.64	7.45	0.50	4.68	1.33	1.00	0.79	0.61	8.91
"Kondine Red"	1.18	3.66	1.78	0.73	0.52	0.53	8.40	0.79	4.53	1.34	1.05	0.39	0.61	8.71
Relative Values	100	100	100	100	100	100	100	52	144	84	116	102	102	108
Tons per acre ...	6.97	17.8	9.56	5.36	3.63	4.28	—	3.60	25.6	8.06	6.26	3.71	4.37	—

difference is probably to be explained by the position of the plants as compared with that of last year.

(b) Overhead Damping versus Non-Damping.

The experiment on the overhead damping versus dry treatment and on the relative effect of these treatments on the setting of the fruit was repeated this year in the first two of the large tomato houses; the position however was reversed as compared with last year, House No. 1 being damped and House No. 2 being kept undamped. House No. 1 is partitioned off from the remainder of the houses, and the tendency of this partition to keep the house warmer is counter-balanced by the outside position of the house and its exposure to east winds. The temperature records show that there is, on the average, very little difference in temperature between the two houses. On the other hand, apart from the damping, the end house always has a higher percentage of humidity. This experiment has now been carried out for four seasons and in three out of four years the second house has given the larger yield, irrespective of the treatment. (See Table III.). Also, in three

Table III.

Crops in lbs. per plant on plots (50 ft. by 13 ft.) containing 250 plants and occupying 5/336 of a house-acre.

VARIETY.	House No. 1. Series G. Damped.							House No. 2. Series H. Non-Damped.						
	Lbs. per plant.						Total. Lbs. per plant. Tons pr acre.	Lbs. per plant.						Total. Lbs. per plant. Tons pr acre.
	June.	July.	Aug.	Sept.	Oct.	Nov.		June.	July.	Aug.	Sept.	Oct.	Nov.	
1. Fillbasket ...	1.29	2.89	0.82	0.72	0.49	0.56	6.77 50.8	1.15	2.95	0.84	0.61	0.83	0.57	6.95 52.1
2. Comet ...	0.59	2.65	0.44	0.59	0.43	0.47	5.17 38.8	0.48	2.22	0.79	0.59	0.74	0.34	5.16 38.7
3. Kondine Red	0.68	2.84	0.82	0.61	0.28	0.72	5.95 44.6	0.77	2.25	1.45	0.58	0.61	0.75	6.41 48.1
4. Ailsa Craig ...	0.94	3.15	0.80	0.82	0.47	0.66	6.84 51.3	0.84	2.85	1.40	0.68	0.62	0.70	7.09 53.2
Relative Values	100	100	100	100	100	100	—	83	89	156	90	168	98	104
Tons per acre ...	6.58	21.6	5.41	5.15	3.13	4.53	— 46.4	6.08	19.2	8.41	4.62	5.26	4.43	— 48.0

years out of four the damped series has given the highest yield for the month of June, the greatest relative increase in each case being given by the variety "Comet," which is strictly in accordance with similar observations on this variety in trade nurseries, where it is almost the only variety which receives this treatment as an aid to the setting of the fruit.

The Manurial Experiments.

(a) Tomatoes.

This series of experiments has this year been modified to a certain extent by the introduction of an unmanured plot.

The increase in crop through the omission of nitrogen in Plot 7, and the absence of benefit and even diminution of crop when nitrogen in any form is introduced is again very striking; this result has been persistent over the last four years. A glance at Table IV. will show that the two series give concordant results, the relative values of the crop returns being in the same sequence. Throughout both series, as the ratio of nitrogen in the soil is increased so the crop falls off. The growth of the plant is increased by the extra available nitrogen and flower production is not impaired, but the setting of the fruit is found to be faulty. The omission of potash has again repressed fruit production, and the addition of dung to complete artificials has given no increase in crop. In connection with these manurial experiments it is convenient to discuss the crop results of the pot-experiments on the nitrogen-potash ratio, using the variety "Comet." As will be seen from Table V. the crop was proportional to the amount of nitrogen present. At first this appears to be quite contradictory to the results obtained in the border experiments during the last

Table IV.
Manurial Experiments with Tomatoes.

Crops in lbs. per plant, grown on plots (22 ft. 8 in. by 13 ft.) containing 120 plants,
and occupying 1/148th of a house-acre.

PLOT NUMBER AND TREATMENT.	Series J. Variety "Comet."										Series K. Variety "Kondine Red."										Mean of Two Series.			
	Lbs. during					Total.					Relative.	Lbs. during					Total.					Relative.		
	June.	July.	Aug.	Sept.	Oct.	Nov.	Lbs. per plant.	Tons per acre.	June.	July.		Aug.	Sept.	Oct.	Nov.	Lbs. per plant.	Tons per acre.							
5 Complete Artificials	0.80	2.26	0.80	0.65	0.38	0.68	5.57	44.2	100															
6 Complete Artificials less phosphates	0.78	2.03	0.79	0.63	0.54	0.61	5.38	42.7	97															
7 Complete Artificials less nitrogen	0.85	2.75	1.11	0.59	0.32	0.36	5.98	47.4	107															
8 Complete Artificials less potash	0.79	2.17	0.67	0.54	0.42	0.36	4.95	39.3	89															
4 Complete Artificials plus dung	0.71	2.13	0.84	0.52	0.56	0.68	5.44	43.1	98															
3 Standard Treatment plus C.A.	0.75	2.06	0.77	0.59	0.45	0.56	5.18	41.1	93															
2 Untreated Control Plot	0.56	2.16	0.69	0.38	0.44	0.55	4.78	37.9	86															
1 Double Complete Artificials	0.57	2.01	0.80	0.49	0.47	0.46	4.80	38.1	86															

four seasons, but it must be borne in mind that the root range in the case of pot culture is strictly limited. The large pots used in this experiment had two-fifths of a cubic foot of soil each; in the borders each plant has at least one cubic foot of

Table VI.

Crops in lbs. per plant grown in borders (32 ft. by 3 ft.) containing 16 plants, and occupying 1/210th of a house acre.

Treatment and Plot Numbers. (Lime added in all cases.)	Lbs. per plant.						Total.		Relative.
	April.	May.	June.	July.	Aug.	Sept.	Lbs. per plant.	Tons pr. acre.	
D1. Loam 2 parts, dung 1 part	4.39	9.70	5.52	6.41	6.30	3.48	35.8	53.7	86
5. " " " " " " " " " " " " " " " "	2.81	10.9	10.1	9.21	9.25	5.02	47.2	70.8	113
2. Complete artificials, no dung	5.43	11.3	7.72	9.60	8.42	2.93	45.4	68.1	109
3. Artificials without nitrogen, no dung	4.47	12.8	7.82	9.28	8.32	3.91	46.6	69.9	111
6. Artificials without phosphates, no dung	4.93	9.31	8.82	11.6	11.3	4.24	50.2	75.3	120
7. Artificials without potash, no dung	6.03	10.6	8.23	11.1	10.4	2.34	48.7	73.1	116
4. Loam only	1.79	9.20	10.8	9.03	10.0	4.48	45.3	68.0	108
8. " " " " " " " " " " " " " " " "	4.41	9.59	7.18	7.96	7.09	2.07	38.3	57.5	92
F1. Loam 2 parts, dung 1 part	5.88	11.3	6.86	9.19	8.32	3.45	45.0	67.5	106
5. " " " " " " " " " " " " " " " "	3.39	10.9	8.89	9.12	7.96	5.14	45.4	68.1	107
2. Complete artificials with added dung	6.17	10.6	8.45	10.8	8.75	4.83	49.6	74.4	117
3. Artificials without nitrogen with added dung	5.46	12.0	9.66	10.6	9.58	4.60	51.9	77.9	123
6. Artificials without phosphates with added dung	4.30	11.5	10.0	10.2	7.53	3.67	47.2	70.8	111
7. Artificials without potash with added dung	5.51	11.9	9.38	9.73	10.3	4.28	51.1	76.7	121
4. Loam only	2.65	11.5	9.29	8.77	7.71	4.18	44.1	66.2	104
8. " " " " " " " " " " " " " " " "	5.55	10.7	6.39	7.15	7.41	3.40	40.6	60.9	96

The other Leaf Spot Disease, *Colletotrichum oligochaetum*, however, does not behave in this way, and as the latter was the particular disease that was prevalent in the district last season, it appeared in the *slow* section of Series C. It is found, however, that this fungus has a maximum temperature of growth round about 85°F. above which its ravages are checked. In Series C the disease was kept under control by the simple expedient of raising the temperature.

As in the case of tomatoes, the forced section shows a marked superiority in the returns for April and May, especially in the former month. (See Table VII.).

Table VII.

Forced and Slow Growth in Cucumbers.

Crops in lbs. per plant grown in borders 18 ft. by 3 ft.) containing 9 plants, and occupying 1/373rd of a house acre.

TREATMENT. Series C.	Lbs. per plant.						Total.		Relative.
	April.	May.	June.	July.	Aug.	Sept.	Lbs. per plant.	Tons pr acre.	
Forced Growth 1 ...	4.47	13.9	10.0	9.23	8.80	1.60	48.0	72.0	105
2 ...	3.48	12.8	9.30	10.8	9.20	1.42	47.0	70.5	
3 ...	4.33	13.0	7.18	10.5	8.11	1.78	44.9	67.4	
4 ...	5.25	12.2	9.90	8.83	8.10	1.72	46.0	69.0	
Slow Growth 5 ...	0.57	10.1	14.4	10.5	7.88	1.35	44.8	67.2	100
6 ...	—	8.10	10.8	8.20	7.80	0.90	35.8	53.7	
7 ...	0.26	10.8	11.2	8.09	8.57	2.58	41.5	62.3	
8 ...	1.50	11.8	13.2	9.60	8.50	1.90	46.5	69.8	

The Value of Soil in Cucumber Culture.

A comparison of freshly-dug and of stacked turf was made in Series F. The manurial treatment was the same in each case, but of the four borders made up with each type of soil, two in each case were deepened to the extent of six inches, to ascertain whether the diminution in crop which is generally experienced in cucumber houses after the first year is in some way connected with the condition of the subsoil.

The results from the four central plots are very concordant and suggest a slight superiority in favour of the fresh turf. (See Table VIII.). The deepening has apparently had little or no effect.

Table VIII.

Value of Soil in Cucumber Culture.

Crops in lbs. per plant grown in borders (32 ft. by 3 ft.) containing 16 plants, and occupying 1/210th of a house acre.

TREATMENT.	Lbs. per plant.						Total.		Relative.
	April.	May.	June.	July.	Aug.	Sept.	Lbs. per plant.	Tons pr acre.	
Fr Stacked Turf	6.98	11.6	9.23	9.55	10.5	3.54	51.4	77.1	106
5 Ordinary depth	2.56	10.1	11.6	9.88	9.70	5.46	49.3	74.0	
2 New Turf ...	7.00	12.9	10.4	8.35	10.0	3.35	52.0	78.0	110
6 Deepened ...	4.45	12.7	10.7	8.66	11.3	4.59	52.4	78.6	
3 Stacked Turf	5.89	11.2	10.1	8.69	10.2	3.82	49.9	74.9	105
7 Deepened ..	5.02	11.7	10.3	8.58	10.1	4.30	50.0	75.0	
4 New Turf ..	2.72	11.0	10.6	9.0	10.7	3.88	47.9	71.9	100
8 Ordinary depth	5.64	10.9	8.95	8.54	8.94	4.23	47.2	70.8	

Soil Sterilisation Experiments.

Experiments in trade nurseries were continued in the same houses and on the same plots as in previous years, at both Nurseries, No. 1 and No. 2.

The results are set out in Tables IX. and X., and in

Table IX.

Soil Sterilisation Experiments. Nursery No. 1.

TREATMENT. House A. 1919	Yield per plant.							Total.		Relative.
	Plot No.	June.	July.	Aug.	Sept.	Oct.	Nov.	Lbs. per plant.	Tons pr acre.	
Steam	1	0.69	1.75	0.85	0.52	0.22	0.26	4.29	34.3	114
Steam	5	0.42	1.70	1.13	0.43	0.20	0.56	4.44	35.5	118
Carbolic	6	0.88	1.69	0.79	0.49	0.25	0.34	4.44	35.5	118
Carbolic	8	0.72	1.66	0.80	0.59	0.27	0.32	4.36	34.9	116
Formaldehyde	3	1.05	1.70	0.75	0.46	0.21	0.26	4.43	35.4	118
Formaldehyde	7	0.98	1.60	0.79	0.48	0.24	0.35	4.44	35.5	116
Untreated	2	0.88	1.33	0.58	0.52	0.23	0.33	3.87	31.0	103
Untreated	4	0.59	1.28	0.64	0.51	0.21	0.41	3.64	29.1	97
House B. 1919										
Steam	2	0.54	1.93	0.80	0.52	0.52	0.46	4.77	38.2	131
Steam	6	0.50	1.83	0.82	0.42	0.48	0.46	4.51	36.1	124
Carbolic	5	0.39	1.65	0.74	0.42	0.44	0.51	4.15	33.2	114
Formaldehyde	8	0.55	1.45	0.70	0.53	0.44	0.33	4.03	34.2	118
Hot Water	4	0.40	1.42	0.50	0.45	0.48	0.45	3.70	29.6	102
Hot Water	7	0.65	1.62	0.59	0.49	0.46	0.37	4.18	33.4	115
Untreated	1	0.41	1.27	0.49	0.53	0.41	0.42	3.57	28.6	98
Untreated	3	0.54	1.35	0.47	0.46	0.46	0.42	3.70	29.6	102

Table X.

Soil Sterilisation Experiments. Nursery No. 2.

TREATMENT. House A. 1919	Yield per plant.							Total.		Relative.
	Plot No.	June.	July.	Aug.	Sept.	Oct.	Nov.	Lbs. per plant.	Tons pr acre.	
Untreated	3	1.21	1.95	0.86	0.44	0.41	0.42	5.29	42.3	99
Untreated	7	1.26	1.89	0.93	0.41	0.46	0.44	5.41	43.3	101
Carbolic	2	1.11	1.62	1.04	0.40	0.44	0.55	5.16	41.3	96
Carbolic	6	1.12	1.76	0.94	0.43	0.55	0.40	5.20	41.6	97
Steam	1	1.24	1.78	1.02	0.40	0.36	0.59	5.39	43.1	101
Steam	5	1.13	2.08	0.93	0.48	0.48	0.53	5.63	45.0	105
Hot Water	4	1.13	2.22	0.90	0.48	0.49	0.54	5.76	46.1	108
Hot Water	8	1.22	1.91	0.93	0.42	0.43	0.52	54.3	43.4	102
House B. 1919										
Untreated	1	1.22	1.86	0.88	0.42	0.53	0.56	5.47	43.8	97
Untreated	5	1.09	2.25	0.83	0.49	0.54	0.58	5.78	46.2	103
Carbolic	4	1.07	1.84	0.89	0.56	0.57	0.56	5.49	43.9	98
Carbolic	8	1.29	1.62	0.91	0.43	0.54	0.58	5.37	43.9	96
Steam	3	1.20	1.78	0.82	0.40	0.52	0.57	5.29	42.3	94
Steam	7	1.32	1.75	0.90	0.34	0.56	0.47	5.34	42.7	95
Hot Water	2	1.24	1.74	0.86	0.42	0.55	0.61	5.42	43.4	96
Hot Water	6	1.18	1.77	0.78	0.43	0.51	0.45	5.12	41.0	91

repect of Nursery No. 1 it is evident that sterilising in all cases had a beneficial effect on the crop yield. This nursery is 19 year's old and the soil is infected with root-knot-eelworm.

At Nursery No. 2 the average yield per acre three years ago was as low as 33 tons. As a result of sterilisation the yield was increased until in 1918 it reached 40 tons per acre. The extra sterilisation in 1919 was without beneficial effect so far as increase in crop was concerned. The results give striking support in the generalisation that when the yield is above 40 tons per acre no form of sterilisation gives a further increase.

Report on the Work of the W. B. Randall Research Assistant from October 1st, 1918, to December 31st, 1919.

The object of the work is to investigate the possibility of controlling undesirable organisms in the soil, and the method of procedure is to study the action on the soil and on the plant of chemical substances likely to serve this purpose.

The chemicals are prepared or examined by Mr. Tattersfield, and their effects on the soil organism and on the plant are studied by Mrs. Matthews. Vegetation experiments are for the present confined to tomatoes grown in borders and in pots.

The following are the main conclusions arrived at during the past two seasons:—

The effects of partial sterilisation on the soil are:—

1.—To increase the supply of nitrogenous food to the plant; in other words, partial sterilising acts in the same way as a nitrogenous manure.

2.—To kill or greatly reduce disease producing and objectionable organisms.

3.—To render for a longer or shorter time the soil less suitable for the growth of plants.

Effect of additional nitrogenous food supply.—This effect is well seen in the extra growth and deeper green colour of plants growing on partially sterilised soil. The effect, however, is not necessarily to increase the yield of the fruit.

1. *In borders.*—At the Cheshunt Experiment Station it is shown that tomatoes growing in borders of fairly good soil do not yield extra fruit as the result of additional nitrogen supply; indeed, in the experimental houses additional nitrogen brought down the yield (p.).

In sterilisation experiments in healthy houses where the soil of the borders is good enough to give a good crop of tomatoes, little or no additional yield was given by any of the methods tested.

At Harpenden nurseries the yields per plant were:—

Blaby. 1919.

Untreated	...	...	...	...	5 lb. 12½ ozs.
Steamed	...	...	...	...	5 lb. 11¼ ozs.
Calcium Sulphide and Naphthalene					6 lb. 2½ ozs.
Various chemicals	...	...	...	...	5 lb. 5 ozs. to 5 lb. 13¼ ozs.

The plants were put out on April 15th, picking began June 7th, the borders were treated with a mixture of artificials only and received no straw manure.

In 1918 the results were similar; thus in the Waltham Cross district where the yield of tomatoes was already good (e.g., over 35 tons per acre) and the plants were all healthy there was no gain in *crop* as a result of sterilising, although the plants on the sterilised soils were distinctly larger and better looking than those on the untreated soils.

2. *In pots*.—In pots, however, the case is entirely different and owing to limitation of root space the effect of nitrogenous dressings is more marked.

In pot experiments at Rothamsted increased yields were obtained by the use of a number of sterilising agents. Thus the following were obtained:—

FILLBASKET.				BLABY.			
Control	...	...	857 grns.	Control	...	...	689 grns.
Chlorpicrin	...	1,480	„	Sodium cyanide			
				& dichlorcresol		892	„
Sodium cyanide		1,377	„	Dichlorcresol	...	856	„
				Sodium picrate	...	830	„
				Chlor-di-nitro-			
				benzene	...	817	„
				Sodium cyanide	..	765	„
				Calcium sulphide		778	„
				Carbolic acid	...	726	„

Effect on disease-producing and objectionable organisms.—This has been made the subject of numerous laboratory experiments. The organism particularly investigated were fungi, free living eelworms, protozoa, bacteria and (by another investigator at Rothamsted, and in another way) wireworms.

The substances tested fall into the following groups:—

	Class 1. Most effective.	Class 2. Less effective.	Class 3. Practically useless.
Fungi.	Chlor-di-nitro-benzene. Dichlor-cresol, Nitro-di-chlor-benzene. Nitro-benzene.	Mono-chlor-cresol Chlor-phenol. o-chlor-nitro-benzene. Cymene. Formaldehyde.	Cresol. Sodium-cyanide. Naphthalene. Chlorpicrin. Picric Acid. Xylol. Toluene.
Eelworm.	Chlor-di-nitro benzene. o-chlor-nitro-benzene. Nitro-di-chlor-benzene. Nitro-benzene. Di-chlor-cresol. Mono-chlor-cresol. Chlorpicrin. Chlorphenol. Picric Acid. Sodium cyanide. Calcium sulphide & Naphthalene.	Cresol. Cymene. Calcium Sulphide	Napthalene at ordinary Laboratory Temperature —about 18°C-22°C
Wireworm.	Chlorpicrin. Chlor-phenol. Steam.	Cresol. Phenol. Nitrobenzene.	Toluene. Carbon disulphide
Beneficial to bacterial activity.	Mono-chlor-cresol. Cymene. Mesitylene. Di-chlor-cresol. Steam, Pseudocumene. Chlorpicrin. Xylol. Nitro-benzene. Chlor-phenol. Lime. Cymene (French) Cresol. Toluol. Sodium cyanide.	Ammonia. Pinene.	Picric Acid. Paranitranilin. Naphtha.

The most interesting feature of the above table is that some half dozen substances have found to possess considerable greater potency than cresol, the chief constituent of the liquid carbolic acid now so much in use: they are also considerably

more effective than the sodium cyanide which has been suggested in America and used with good effect.

Of these substances, chlorpicrin, one of the most effective, is obtainable in large quantities at low price, but the practical difficulties of application have not yet been completely surmounted. A mixture of the chlor-cresols could be easily prepared, and also of the chlorphenols, and neither would be more difficult to use than liquid carbolic acid.

Sodium cyanide is obtainable, but not easily at present. The nitro compounds are at present too costly for use. Larger scale experiments with some of the more promising substances will be arranged.

Objectionable action on plants.—Most substances that act adversely on objectionable organisms also act adversely on growing plants. Fortunately, however, many organic compounds are decomposed in the soil, and all in the above list disappear fairly quickly.

Pot experiments showed that an interval of 20 to 30 days was necessary for doses that would probably be effective in dealing with soil pests.

Effect on root action.—One of the substances tested, viz., chlorpicrin, had a remarkable effect on root action, producing the great mass of fibrous roots which has hitherto only been obtainable on a steamed soil. Many attempts have previously been made to reproduce this effect of steaming, but until this season without success.

Report of the Mycologist.

The investigations, which began in May, 1919, have been directed mainly towards "Damping off" and "Stripe" of Tomato plants, but a considerable amount of general work has also been done.

The diseases which have been brought to notice during the past season are listed below:—

Tomato.				Parasite.
Disease.				
"Damping off"	...	...	...	<i>Phytophthora spp.</i> and <i>Rhizoctonia solani.</i>
"Foot rot"	...	...	...	<i>Phytophthora sp.</i>
"Buck eye rot" of the lower trusses				<i>Phytophthora terrestris</i> = <i>P. parasitica.</i>
"Stripe"	...	...	...	<i>Bacillus lathyri.</i>
Destruction of leaf bases and stem...				<i>Botrytis sp.</i>

Mottling of leaves	...	...	...	Cause at present unknown, may be mosaic disease.
"Sleepy disease"	...	...	...	<i>Verticillium sp.</i>
Fruit diseases	...	...	...	<i>Macrosporium solani</i> , <i>Verticillium sp.</i>
				Bacterial rot (organism under investigation).
				<i>Penicillium sp.</i>
"Blossom end rot"	...	...	...	Physiological cause.
Destruction of green fruit	...	...	...	<i>Rhizopus nigricans.</i>
Cucumber.				
"Leaf spot"	...	...	...	<i>Colletotrichum oligochaetum.</i>
"Wilt"	...	...	...	<i>Verticillium sp.</i> and <i>Fusarium sp.</i>
Vine.				
Fruit rot	...	...	...	<i>Rhizopus nigricans.</i>
Chrysanthemum.				
Bronzing of lower leaves	...	...	...	Eel worm (<i>Aphelenchus</i>).

It would be a great assistance in disease investigations if each grower would notify the Station of any occurrence of diseases. A disease apparently commonplace, may chance to be of great importance.

An attempt is being made to trace the many sources of infection, so any diseased plants (weeds, shrub or trees) growing in the vicinity of nurseries would be especially valuable.

"Stripe" Disease of Tomato.

The following report is written jointly by Mr. W. F. Bewley and Dr. S. G. Paine, of the Imperial College of Science and Technology, London. The two authors isolated the same organism independently and finding they were studying the same disease agreed to collaborate.

The disease of tomatoes known to the nurserymen as "Stripe" is characterised by brown longitudinal markings or stripes on the stem, by shrivelling of the leaves, and by sunken irregularly shaped pits usually of a brown colour on the fruit. It is a specific communicable disease and is due to a bacillus, which has been previously described as the cause of a very similar disease of the Sweet Pea. So far little is known concerning the geographical distribution of the disease. It is

very common on tomatoes grown under glass in this country and in the Channel Islands. There is no doubt that it occurs also in parts of Canada and the United States.

Certain facts indicate the soil as the main source of infection, and Howitt and Stone have shown that plants grown in soil from an infected house developed the disease, while plants grown in the same soil previously sterilised remained free. The disease may appear in the seed-boxes, producing a rapid destruction of the young plants and thus necessitating fresh sowings. It is not uncommon to find the first symptoms of disease while the young plants are still in the small pots or again soon after they have been planted out. Usually, however, the disease first appears about May when the earliest fruit is ready for picking, but frequently no signs appear until the "tops" are allowed to develop, when these often become badly attacked. There is a distinct connection between soft and rapid growth and the incidence of disease, plants growing rapidly in the early stages are more liable to "Stripe" than others of a hardier nature.

Observations on the Experimental Plots.

During the past season observations have been made on the manurial plots in the houses at Cheshunt to ascertain the relation of manurial treatment to the incidence of the disease. The indications are that a soft rapid growth such as is produced by excess of nitrogen without potash and by a high temperature accompanied by damping renders the plant more susceptible to "Stripe." The beneficial effect of potash is well shown.

The Effect of Different Manurial Treatments on the Incidence of Stripe.

Variety.	Treatment.	Total No. of plants.	No. of diseased plants.
Comet	*C.A. without Potash	120	78
"	Control untreated	120	50
"	C.A. with dung	120	45
"	C.A. without Phosphates	120	41
"	C.A. ...	120	40
"	C.A. without nitrogen	120	34
"	Double C.A. ...	120	34
Kondine Red	C.A. without potash	120	33
"	C.A. with dung	120	34
"	Control untreated	120	30
"	C.A. without phosphates	120	28
"	C.A. without nitrogen	120	19
"	Double C.A. ...	120	14
"	C.A. ...	120	13

* C.A.=Complete Artificials.

The Effect of Damping on the Incidence of the Disease.

Variety.	Damped.		Non-damped.	
	Total plants.	No. striped.	Total plants.	No. striped.
Comet	260	124	260	110
Fillbasket ...	260	112	260	95
Kondine Red ...	260	112	260	82
Ailsa Craig ...	260	95	260	34

The Effect of Forced and Slow Growth on the Incidence of the Disease.

Variety.	Forced Growth.		Slow Growth.	
	Total No. of plants.	No. of diseased plants.	Total No. of plants.	No. of diseased plants.
Fillbasket ...	100	58	100	44
Comet	100	38	100	26
Kondine Red ...	100	24	100	14
Ailsa Craig ...	100	24	100	16

These observations are fully confirmed by inoculation tests carried out on plants grown in pots, the results of which will be found under the heading "Inoculation Experiments."

Besides showing the effect of manurial treatment and of forcing conditions these tables bring out clearly marked differences in the relative susceptibility of the varieties tested and point to the selection or breeding of a resistant variety as one means of controlling the disease.

The Mode of Infection.

As stated above infection usually takes place underground. The frequent occurrence of the disease in the seed-bed suggests that the seed from infected fruit may also be infected or carry the causal organism externally. This problem is at present under investigation, and although certain facts point to transference of the disease by the seed, it is not yet time to make a definite statement. Observations in nurseries and practical experiments have shown that the disease may sometimes spread downwards, successful "prick" infections have been made on the upper parts or plants which indicate that insects may produce infection of the aerial parts. It is also fairly certain that the pruning knife is a potent factor in spreading the disease.

Symptoms of the Disease.

The stem of an attacked plant shows the earliest symptoms of disease as light or dark brown sunken patches of irregular shape, varying from small spots to long furrows and "blazes"; the "blazes" are often three or more inches long and frequently extend over the entire length of an internode. In slight cases these markings occur intermittently along the

stem, while in bad cases the typical furrows can be found throughout the whole length of the stem and on the leaf and truss stalks. The name "Stripe" aptly describes this distinctive feature of the disease, but it should not be confused with the "Black Stripe" supposed to be due to *Macrosporium solani*. There is, however, considerable doubt whether "Black Stripe" is a distinct disease. It seems highly probable that *Macrosporium solani* exists as a saprophyte upon the tissue destroyed by the "Stripe" bacillus.

Morbid Anatomy.

Lesions in the pith and cortex are the characteristic internal features of the disease, the walls of the attacked tissues are strongly browned so that the brown patches are readily seen on splitting the stem. In old stems which have become hollow small brown patches occur in the remains of the pith and the cortex, but at the nodes where the pith is moist the patches are much larger. The roots are often found to be diseased only in the upper portion, and infection can usually be traced to some wound or insect puncture just below the ground level; the tissues of the lower parts are in these cases white and apparently healthy.

In some cases, however, no wound can be discovered, but the cortex of the root is found to be browned to a considerable depth below the ground level, and microscopic examination shows the presence of the bacillus in the tissue. It seems that penetration of the root may occur without the aid of a wound, but of course there is always the possibility that a small wound has escaped observation or again that the disease has spread down to the root from an aerial infection.

Isolation of the Organism.

The organism was first isolated in 1918 from badly attacked plants. Sections of the stem showed no signs of active bacteria and several attempts to isolate the organism from the stem proved abortive. Finally the causative organism was isolated in pure culture from several fruits and two stems.

The causal organism is a small yellow bacillus believed to be identical with *Bacillus lathyri*, Manns and Taubenhaus.

Inoculation Experiments.

PRELIMINARY EXPERIMENTS.

- 28/5/19. Six young tomato plants (Comet Variety) were used. The stems were washed with alcohol and then with sterile water. A small piece of culture was "pricked in" near the top of the plant and the wound covered with tinfoil to avoid secondary infection.
- 31/5/19. Brown corky patches appeared round the stab.
- 11/6/19. Black furrows up and down the stem from the stab—three inches up and two down.

- 28/5/19. Six young plants as in the previous experiment were used. Inoculations were made by "pricking in" bacteria from a pure culture near the base of the plant and covering as before.
- 14/6/19. Black furrows eight inches up the stem. Lower pair of leaves attacked.
- 30/6/19. Plants show numerous lesions.
- Three controls were perfectly healthy.
- 28/5/19. Six plants removed from the soil and their roots well washed. Finally they were washed in alcohol followed by sterile water. They were inoculated by rubbing bacteria from a pure culture on the roots; they were then re-planted.
- 15/6/19. First brown patch appeared on the stem about half an inch above the soil level.
- 29/6/19. Lesions on the stem seven inches from the ground.
- 5/7/19. Plants badly attacked.
- Three controls quite healthy.
- 5/7/19. Organism re-isolated from representative members of each experiment.
- 3/6/19. Four plants two feet high were inoculated by rubbing bacteria from a pure culture on a rough leaf base such as is left by careless pruning.
- 9/6/19. Bases blackened and furrows appear which run from the leaf base to the stem.
- 15/6/19. Furrows on the stem reach two inches below the inoculated base.
- 3/7/19. Furrows reach up and down the stem. First and second pair of leaves above, and the first pair below, the point of inoculation are attacked.
- The two controls healthy.
- 3/6/19. Four plants two feet high were used. Several badly striped leaves were crushed in a mortar and the juice rubbed into a carelessly pruned leaf base.
- 11/6/19. Bases blackened.
- 30/6/19. Typical furrows running from the bases into the stem were visible.
- 21/7/19. The plants were all badly "striped."
- 3/6/19. Four green tomato fruits after sterilising the outside were inoculated by "pricking in" bacteria from a pure culture.
- 10/6/19. Brown ring round the stab.
- 17/6/19. Brown sunken patch round the stab. The fruit was cut open when it was found that the tissue round the stab was browned.
- A brown patch was present in the loculus wall from which the organism was re-isolated.
- The control fruit showed the wound healed and no sign of disease.
- 20/7/19. The organism re-isolated from inoculated plant on 5/7/19 was "pricked" into six twelve inch plants.
- 29/7/19. Typical furrows on stem near the wound.
- 4/8/19. The organism was again isolated and found to be identical with the original.

The effect of manuring upon the results of artificial infection.

A standard soil compost was made up as follows :—

72 cubic feet of virgin soil.

32 lbs. lime.

8 „ bone meal.

8 „ bone flour.

72 twelve inch pots were each given one cubic foot of the compost
To these pots nitrogen in the form of ground hoofs and potash as

sulphate of potash were added in varying amounts. Each series consisted of eight pots planted with uniform tomato plants of the variety Comet.

Series 1.—1 c. ft. compost and 1/9 lb. Hoofs per pot	} No Potash.
“ 2 “ “ “ 2/9 “ “ “ “ “ “ “ “	
“ 3 “ “ “ 3/9 “ “ “ “ “ “ “ “	
“ 4 “ “ “ 1/9 “ Sulphate of potash per pot	} No Nitrogen.
“ 5 “ “ “ 2/9 “ “ “ “ “ “ “ “	
“ 6 “ “ “ 3/9 “ “ “ “ “ “ “ “	
“ 7 “ “ “ 1/9 “ Hoofs and 1/9 lb. sulphate of potash per pot ..	} Nitrogen and Potash.
“ 8 “ “ “ 2/9 “ Hoofs and 2/9 lb. sulphate of potash per pot ...	
“ 9 “ “ “ 3/9 “ Hoofs and 3/9 lb. sulphate of potash per pot ...	

28/5/19. Six plants of each series were inoculated by “pricking” in some of the culture into the lower portion of the stem, and covering the wound with a piece of tinfoil to prevent secondary infection. Two plants of each series were left as controls; they were pricked with a sterile needle and covered in the usual way.

SERIES 1.

31/5/19. Brown corky appearance round the stab.
12/6/19. First pair of leaves above the wound showed typical stripe lesions. Furrows three inches up the stem.
20/6/19. Plant typically striped two feet up the stem.

SERIES 2.

31/5/19. Lesions round the prick were more distinct than in Series 1.
12/6/19. Furrows nine inches up the stem.
20/6/19. Lesions more advanced than in Series 1.

SERIES 3.

31/5/19. Discolouration still more intense than in Series 2.
12/6/19. Furrows up the stem eleven inches.
20/6/19. Five out of the six plants showed lesions in the tops. The sixth one had the top seven inches clean.

SERIES 4.

31/5/19. Slight discolouration round the prick.
12/6/19. Furrows two inches up the stem from the wound.
20/6/19. Very little stripe on four plants, but two showed lesions on the first pair of leaves above the wound.

SERIES 5.

20/6/19. Very little stripe showing on any plant.

SERIES 6.

No stripe at all, except in one case where the plant had rooted through the pot into the rich soil beneath.

SERIES 7.

Similar appearance to plants in Series 1.

SERIES 8.

Similar to Series 1.

SERIES 9.

12/6/19. Similar to Series 2. Furrows up to three inches above the wound.
20/6/19. Third pair of leaves above the wound attacked. All controls were healthy.

21/8/19. The preceding experiment was repeated with precisely the same results. The indications were that increasing amounts of Nitrogen without Potash produced an increasing susceptibility to the disease, while increasing amounts of Potash without Nitrogen gave a corresponding increase in resistance to it. Where Potash and Nitrogen were used together there were indications that the Potash counteracted the effect of the Nitrogen.

Control of Stripe Disease.

Several methods are suggested :

- (1) Sterilisation of the soil by heat.
- (2) Sterilisation of the seed by means of formalin.
- (3) Selection of resistant varieties.
- (4) Sterilisation of the pruning knife in cases where the disease has been noticed, especially while pruning the diseased plant and before passing from a diseased plant to healthy ones. This might easily be effected by wiping the blade of the knife with a rag soaked in 2% Lysol or "carbolic." The prunings from diseased plants should not be thrown on the ground but carefully collected and burnt.
- (5) The cutting away of a diseased stem and allowing a lateral to develop will sometimes give a clean plant.
- (6) In the use of artificial manures potash should be present in sufficient quantity and nitrogen not too abundant.

"Damping off" of Tomato Seedlings.

"Damping off" is a term commonly used by nurserymen to describe the death of very young seedlings. Generally the highest death rate has occurred after periods of watering and this has led growers to draw a close connection between the disease and damping, and has given rise to the name "Damping off." Properly speaking the term applies to a fatal disease set up through the agency of parasitic fungi, but it is often made to embrace the wilting of seedlings caused by some injurious chemical or physical factor in the soil. These latter causes of death are of somewhat rare occurrence and when they do take place may usually be traced to carelessness on the part of the workman. Our investigations have been directed towards the congeries of diseases caused by pathogenic fungi.

At the outset one is faced by a number of possible sources of infection all of which require careful investigation if complete control of the disease is to be effected. The seeds themselves, the seedboxes and soil, the stages upon which the boxes rest, and the water used in cultivation are all possible sources of infection.

The Seeds.

It is well known that the seed coats of many seeds carry fungus spores which germinate in the soil and destroy the young root as it emerges. The tomato seed is especially suitable for carrying spores, its seed coat being provided with long hairs can hold small particles. When it is remembered how difficult it is to remove the particles of sand used in the extraction of seeds from the fruit, it will be seen how well the seed coat can retain such small bodies as fungus spores. An examination of many different samples of seeds has shown, as one might expect, that they carry on their testas a very varied fungus flora, but so far we have been unable to find any active parasites. This of course does not prove that tomato seeds never carry destructive organisms but it indicates that such is a rare occurrence. The hairiness of the seed coat and the presence of many fungus spores point to the fact that disease organisms may be carried also. It is advisable to test all bought seed in a trial box some time before the general sowing; seed suspected of impurity should be sterilised. Home produced seed should be free from disease, provided it came from the best fruits and was extracted under hygienic conditions. The extraction of the seeds should not be carried on near a growing plant. The fruit should be washed, carefully dried and carried to some clean shed or room where the air is still and there the seed should be removed. It is unnecessary and undesirable to allow too long a time for the preliminary rotting of the mucilage.

Seedboxes and Pots.

General observation and experimental work show that the disease organisms are carried over from one season to the next by seedboxes and pots. Discoloration and destruction of plant roots has frequently been traced to some crack or crevice in the pot or box which has harboured the resting spores of the fungus.

The Soil.

The organisms producing "Damping off," like many others, spend part of their existence in the living plant and the rest in hibernation over the winter in the decomposing soil humus. So far as we have been able to determine, "Damping off" of Tomato seedlings is produced by three different organisms which appear to be *Phytophthora terrestria* (Sherbakoff), *Ph. cryptogea* (Pethybridge), and *Rhizoctonia solani* (Kühn), respectively, though precise identification is not possible until comparisons of pure cultures are completed. *Ph. terrestria* also produces "Buck-eye rot" of Tomato fruits, stem rot of the Tomato, and stem-rot of the Lupin. *Ph. cryptogea* has been

described as producing "foot-rot" of the Tomato and Aster. *Rhizoctonia solani* is regarded as a universal soil organism which attacks young plants.

The Water Supply.

Observations in nurseries where epidemics of "Damping off" and "Foot rot" have been in progress led us to suspect the water as being an important source of infection. Preliminary experiments on seedlings, watered with water suspected of contamination, confirmed this suspicion. We have therefore undertaken an extensive analysis of nursery waters in the Lea Valley to ascertain what organisms pathogenic to the Tomato they contain. The results which will be given later, show that while some waters are practically free from pathogenic organisms, others contain the spores of many Tomato parasites. The problem of pure water supply is exceedingly important and requires very careful investigation. One important precaution is to avoid all danger of polluting the well by surface drainage from the nursery, or any allotment, garden, etc.

Experimental.

An examination was made of diseased seedlings from various nurseries in the district. The pathogenic organisms were identified, isolated in pure culture and tested for pathogenicity. The dominating pathogen, here called *Phytophthora* "A," appeared to be identical with *Ph. terrestris* described by Sherbakoff in America as producing "Buck-eye rot" of Tomato fruits, and stem rot of Citrus trees and Lupins, and is probably identical with *Ph. parasitica* described by Dastur in India as attacking Castor Bean plants. Nearly equal in importance is *Ph.* "B," probably *Ph. cryptogea*, which has been described by Pethybridge as producing a foot rot of the Tomato plant. In a few cases *Rhizoctonia solani* was the causative organism. Samples of soil were then obtained from several nurserymen and tested for their power to produce "Damping off." Throughout the whole of our experiments, sterile seed boxes, soil at the rate of five pounds per box, disease free seed selected by sifting, and sterile water were used. Seed-boxes were "made up" from the soil samples and seeds were sown in the usual manner. Where "damping off" occurred one or more of the above mentioned fungi was invariably found.

Experiments were set up to test the effect of different methods of making up the seed boxes upon the incidence of the disease. The standard method was to weigh out five pounds of soil into each box. Then the soil was compacted by means of a builder's board, soaked with water, 100 seeds per box were sown and covered with a thin layer of sterile soil.

Table I.

Soil.	No. of boxes.	Parasitic organism.
From trade nurseries	10	<i>Phytophthora</i> "A"
" " "	3	" " & <i>Rhizoctonia solani</i> .
" " "	5	<i>Ph.</i> "B" & <i>Rhizoctonia solani</i> .
" " "	6	" "
New turf	3	No disease.
Old turf (Station)	3	" "
" (Trade nursery)	3	<i>Ph.</i> "A."
Old cucumber borders	3	No disease.
" " "	3	<i>Ph.</i> "A."
Tomato house (Station)	3	" "
Tomato house sweepings (Station)	3	" "
Sandy subsoil	3	No disease.
Baked soil	3	" "
Steamed soil... ..	3	" "

Table II.

Treatment.	Infected Soil.		Sterilised Soil.	
	Av. % Germinatn.	Av. % Diseased.	Av. % Germinatn.	Av. % Diseased.
Seed covered with $\frac{1}{4}$ " sand... ..	95	36	95	none
" " " $\frac{1}{4}$ " charcoal	97	47	96	"
" " " $\frac{1}{4}$ " lime	96	66	95	"
" " " $\frac{1}{4}$ " sterile soil	96	45	99	"
Seed covered with $\frac{1}{4}$ " sterile soil, then $\frac{1}{4}$ " sand ..	95	39	100	"
" " " " " " " $\frac{1}{4}$ " charcoal	94	45	97	"
" " " " " " " $\frac{1}{4}$ " lime ...	97	60	96	"
" " " " " " " $\frac{1}{4}$ " lime and charcoal	96	53	97	"
Seed covered with $\frac{1}{4}$ " sand, then $\frac{1}{4}$ " charcoal ...	95	40	99	"
95% soil + 5% charcoal	97	33	98	"
75% " + 25% "	96	25	97	"
50% " + 50% "	94	20	95	"
95% " + 5% lime	98	69	97	"
75% " + 25% "	95	51	96	"
90% " + 5% lime + 5% charcoal	97	37	96	"

In certain instances, however, sand, lime or charcoal was used in place of the sterilised soil. In other cases a layer of sand, lime or charcoal was put on over the sterile soil; and in still other cases the soil was mixed with different proportions of sand, lime or charcoal. A parallel set of experiments was set

up at the same time, using sterilised soil. Diseased seedlings were removed from the boxes as soon as they were attacked in order to eliminate the factor of superficial spreading of the disease.

The results of these experiments show that none of these methods suffices to control the disease. The addition of lime in some cases is actually harmful and increases the amount of disease. This is in agreement with the fact that the parasitic organisms grow best in a neutral medium. One point worthy of note is the beneficial result obtained by the addition of charcoal—in all cases it resulted in a dark green healthy growth.

The relation of the closeness of sowing to the spread of the disease.

In order to ascertain the correct closeness to sow the seeds, and the effect of closeness of sowing upon the incidence of the disease the following experiments were made. Seeds were sown in infected soils in numbers varying from 600 to 25 seeds per box, in sets of four boxes at each degree of closeness. In half the boxes the seedlings were removed, as they were attacked, to eliminate the factor of spread. The remainder were untouched and gave some indication as to the rate of superficial spread of the fungus.

Table III.

No. of seeds per box.	Average % diseased seedlings removed when attacked.	Average % diseased seedlings not removed.
600	51	100
300	45	100
200	49	100
100	42	78
50	37	46
25	35	41

The second column of the above Table shows the uniform results obtained when the seedlings were removed as they were attacked. It indicates that the number of seedlings primarily attacked depends upon the number of disease centres in the soil and not upon the closeness of sowing, when the factor of superficial spread of the organisms is eliminated. The third column, where the fungi were allowed to spread, is of great practical interest and shows that the rate of spread of the organism is more rapid, where the seeds are closely sown, than where they are thinly sown. In the closer sowings the density of the plants increases the film of water adhering to the seedlings and offers a ready means of spreading the disease through the box. Sowings above fifty to the box should be avoided as they materially assist the disease.

The relation of the time and method of watering to the incidence of the disease.

In the following experiments we attempted to ascertain the time and method of watering which would produce a minimum of diseased seedlings. The seedlings were removed as soon as they became diseased.

Table IV.

Method of watering.	No. of seeds per box.	Average % diseased.
Top watering—evening	100	42
" mid-day	100	54
" morning	100	45
Stood continuously in tray of water	100	73
Bottom watering, when necessary..	100	27

The results obtained indicate that either morning or evening watering is preferable to midday watering and that bottom watering is preferable to top watering. For bottom watering the seed boxes were placed for five minutes each in a zinc tray $\frac{1}{2}$ inch deep filled with water.

The effect of Potash, Phosphates and Nitrogen upon the incidence of the disease.

One hundred seeds per box were sown, covered in the usual way, and the seedlings removed as soon as they became diseased.

Table V.

Treatment.	No of Boxes.	No. of Seeds per Box.	Av. % Diseased.
11 gms. Sulphate of Potash per 5 lbs. soil	10	100	11
" Nitrate of Soda " " " " " " " " " " " "	"	"	49
" Superphosphate " " " " " " " " " " " "	"	"	43
" Sulphate of Potash and Nitrate of Soda per 5 lbs. soil	"	"	45
" Sulphate of Potash and Superphosphate per 5 lbs. soil	"	"	29
" Nitrate of Soda and Superphosphate per 5 lbs. soil	"	"	51
Control (untreated)	"	"	45

The above results indicate that a dressing of Sulphate of Potash is useful in reducing the amount of disease.

Fungicides.

In these tests the boxes were made up in the usual way, using infected soil; 100 seeds per box were sown and covered; the fungicidal solutions in the quantities shown in Table VI. were then applied from a copper sprayer. The boxes were left until the seeds germinated, when the percentage germinated and the percentage diseased seedlings were determined. Each diseased seedling was removed as it fell over.

Table VI.

Treatment.	No. of boxes.	Av. % germination.	Av. % diseased seedlings.
Control	6	97	45
400 ccs. 2% solution Copper Sulphate	"	9	25
" " 1% " " "	"	37	43
" " 1% " " "	"	94	41
" " 2-3-50 Bordeaux mixture	"	95	37
" " 4-4-50 " "	"	93	28
" " 4-4-100 " "	"	97	39
" " 2-3-50 Burgundy mixture	"	92	39
" " 1 in 25 Formaldehyde solution	"	0	0
" " 1 " 50 " "	"	0	0
" " 1 " 100 " "	"	93	40
" " 1 " 250 " "	"	95	47
" " 0.75% solution Sodium fluoride	"	25	7
" " 0.5% " " "	"	98	23
" " 0.1% " " "	"	96	43
" " 0.5% " Barium polysulphide	"	93	47
" " 0.01% " Phenol	"	95	45
" " 1/4 oz. Sodium chloride (sprinkled over the soil)	"	97	39

The results obtained indicate that none of the solutions tested are able to control the disease without injury to the plants.

Control of the disease by soil sterilisation.

Sterilisation of the soil by heat or formaldehyde has proved the most effective method of controlling "Damping off."

Sterilisation by steam.

Twelve boxes of naturally infected soil and twelve of inoculated soil were prepared, six of each were steamed for two hours and the remaining six of each were left untreated to serve as controls; after cooling, the whole twenty-four boxes were sown in the usual manner, 100 seeds per box, and the seedlings removed as they became diseased. The seedlings in the steamed soil were perfectly healthy, while the unsteamed

controls showed an average of 47% of diseased plants. Apart from the control of the disease, the steamed soil gave much the best type of seedlings. They were more healthy and vigorous and showed better root development than those in the untreated soils. The steaming also killed all the weeds.

Sterilisation by baking gave similar results.

Sterilisation by Formaldehyde.

Formaldehyde has long been recommended as a soil fungicide. The soil in the boxes was saturated with different concentrations of formaldehyde; it was then covered for 48 hours to allow the vapours to act. After this time had elapsed the covers were removed and the soil allowed to dry; seeds were then sown in the usual way.

Table VII.

Strength of sterilising solution.	Average number of diseased seedlings per box.
1 cc. 40% formaldehyde per 200 ccs. water ...	44
1 " " " " 150 " ...	45
1 " " " " 100 " ...	42
1 " " " " 75 " ...	37
1 " " " " 50 " ...	0
1 " " " " 25 " ...	0
1 " " " " 10 " ...	0

Our results show that all strengths of formalin solutions from 2 per cent. upwards are effective in soil sterilisation. The weaker solutions are not sufficiently strong to completely sterilise the soil. Our untreated controls in the above experiments gave an average of 48 per cent. diseased seedlings.

Further experiments showed that complete sterilisation of the diseased soil could be carried out by the following method. A formaldehyde solution is made by adding one ounce of commercial Formalin (40 per cent. formaldehyde) to two-and-a-half pints of water (*i.e.* 1 in 50). The soil is saturated with this solution, covered with glass for 48 hours, allowed to stand uncovered for 10 days to make sure all the Formaldehyde has evaporated; the seed is then sown in the usual manner. So long as the water is not infected this treatment will ensure a healthy batch of seedlings.

The seed-box as a carrier of disease.

Twenty-four boxes in which "damping off" had been very severe were used. Twelve were left untreated as controls and the remaining twelve were soaked for ten minutes in a 2% solution of Formalin contained in a tub, then placed in a heap and covered with sacking for 48 hours in order to allow

the vapours of the Formaldehyde to act upon the fungi present in the boxes. After 48 hours the sacking was removed and the boxes allowed to dry. All the boxes both treated and untreated were then made up with sterilised soil, sown with sterilised seed, watered with sterile water and placed on sterilised glass plates in the greenhouse. The plants grown in the sterilised boxes were perfectly healthy and showed no signs of "damping off," while 11 boxes out of 12 untreated showed an average of 14% diseased seedlings.

This experiment shows that seed boxes carry the infection from one season to another.

Table VIII.

Date.	Untreated boxes.	Treated boxes.
7/8/19	Seed sown	Seed sown.
20/8/19	One box showed disease ...	All boxes with healthy plants.
30/8/19	Five boxes showed disease	" " " " "
7/9/19	Nine " " "	" " " " "
23/9/19	Eleven " " "	Two diseased seedlings in one box.
7/10/19	" " " "(One box with healthy plants)	" " " " "

The pot as a carrier of disease.

Twelve pots which had previously contained plants attacked by "foot-rot" were obtained from a nursery, six were treated with a 2% solution of Formalin in the same manner as the boxes in the previous experiment, while six were left untreated to serve as controls. In four of the six untreated pots the plants developed "foot-rot" while in all six treated pots the plants grew perfectly healthily.

Sterilisation by Formaldehyde of the soil in heaps.

The soil used in the experiment was naturally infected soil obtained from a nursery; it was tested and found to produce the disease quite readily. Two heaps were made each of 60 lbs.; one was left untreated and into the other was gradually worked 2 gallons of a 2% solution of Formalin, thoroughly mixing with a spade; it was then covered with sacking for 48 hours. The sacking was then removed, the heap spread out and allowed to dry. Fourteen days after treatment nine boxes and six pots were filled from each heap. The boxes were sown with sterile seed and the pots planted with young healthy seedlings reared in sterilised soil. In each case sterile water was used for watering. The treated soil produced plants free from disease, while the untreated soils in

the nine boxes showed an average of 48% of diseased plants and five pots out of six contained plants affected with "foot-rot."

The time after treatment at which it is safe to sow.

Twenty-four boxes were made up with naturally infected soil. Twenty were treated with a 2% solution of Formalin, covered, and sown in pairs on successive days. One hundred seeds were sown per box, and the infected seedlings were removed as soon as they were attacked.

Table IX.		
Time of sowing.	% germination.	% diseased.
On removing covers	49	0
1 day after ...	57	0
2 days after ...	69	0
3 " " ...	51	0
4 " " ...	100	0
5 " " ...	97	0
6 " " ...	98	0
7 " " ...	93	0
10 " " ...	94	0
14 " " ...	98	0

The untreated controls showed an average of 44% diseased seedlings per box.

In this experiment it was safe to sow from four to seven days after treatment, but in practice it is better to allow a fortnight interval for the vapours to pass completely out of the soil.

Treatment after disease has appeared.

Numerous attempts have been made to stop the disease once it has become established in the seed-box. In our experiments the diseased seedlings were removed and the remainder were sprayed with different fungicides, or treated as indicated in Table X. None of the common fungicides were effective in stopping the attack. As it was found in the laboratory that the organisms only flourish in neutral media it was thought that treatment with acids might control them. So far however it appears that the strength of acid necessary to kill the organisms also kills the seedlings.

Table X.

Treatment.			% Diseased.
Mixture of charcoal and lime sprinkled from above...	...	...	44
Sodium fluoride (0.5% solution)	400 ccs.	...	43
" " (0.75% solution)	"	...	injured seedlings.
Formaldehyde (1% solution)	"	...	killed seedlings.
" (0.5% solution)	"	...	34
" (0.13% solution)	"	...	43
Sodium nitrate (0.5% solution)	"	...	45
Sulphate of Potash (0.5% solution)	"	...	32
Sulphuric acid (1% solution)	"	...	killed seedlings.
" (0.25% solution)	"	...	" "
" (0.125% solution)	"	...	42
" (0.05% solution)	"	...	44
Citric acid (0.5% solution)	"	...	40
" (1% solution)	"	...	41
" (2% solution)	"	...	43

The above results indicate that none of the compounds tested will control the disease once it has started.

Conclusion.

(1) "Damping off" of Tomato seedlings is a communicable disease due to a congeries of pathogenic organisms, particularly species of *Phytophthora*.

(2) The organisms do not occur in all soils but exist as a definite infection in some.

(3) Infection of the seedlings comes primarily from the soil and from water.

(4) Seed boxes and pots can carry on the infection from one season to the other.

(5) Careless watering is frequently responsible for the rapid spread of the disease. By sowing no closer than fifty seeds to the box, carefully regulating the watering, and picking out the diseased seedlings as they occur, the disease may be reduced to a minimum.

(6) Soil sterilisation by heat or by Formaldehyde completely frees the soil from the disease organisms, and, thus provided the water is non-infective, gives complete protection. In order to ensure a healthy crop of seedlings all seeds should therefore be sown in sterilised soil and watered with pure water.

APPENDIX.

Manurial Experiments with Tomatoes.

HOUSE NO. 3, SERIES J. Variety "Comet."

HOUSE NO. 4, SERIES K. Variety "Kondine Red."

(Eight equal plots of 32 square yards area in each house; 120 plants per plot; lime given to all plots).

J. 1 and K. 1. Double complete artificials, *i.e.*, double the treatment in J. 5 and K. 5.

J. 2 and K. 2. Untreated control plots.

J. 3 and K. 3. Standard plus complete artificials equivalent in nutritive value to half the standard.

Before Planting—Standard winter dressing consisting of 14 lbs. of straw manure, 0.5 lb. bone-meal, 0.5 lb. bone-flour, 0.5 lb. ground hoofs, and 0.5 lb. sulphate of potash per square yard, together with an additional 0.1 lb. of sulphate of potash and 0.4 lb. of basic slag per square yard.

After Planting, in four equal instalments—0.2 lb. sulphate of ammonia, 0.2 lb. nitrate of soda, 0.5 lb. super-phosphate, and 0.2 lb. sulphate of potash per square yard.

J. 4 and K. 4. Complete artificials plus dung.

Before Planting—7 lbs. straw manure, 0.4 lb. basic slag, and 0.1 lb. sulphate of potash per square yard.

After Planting, in four equal instalments—0.2 lb. sulphate of ammonia, 0.2 lb. nitrate of soda, 0.5 lb. super-phosphate, and 0.2 lb. sulphate of potash per square yard.

J. 5 and K. 5. Complete artificials only.

The same as plots J. 4 and K. 4 with the omission of straw manure.

J. 6 and K. 6. Complete artificials less phosphates.

The same as in plots J. 4 and K. 4 omitting straw manure, basic slag and superphosphate.

J. 7 and K. 7. Complete artificials less nitrogen.

The same as in plots J. 4 and K. 4 omitting straw manure, sulphate of ammonia and nitrate of soda.

J. 8 and K. 8. Complete artificials less potash.

The same as in plots J. 4 and K. 4 omitting straw manure and sulphate of potash.

Dates of Sowing, Potting, Planting, Picking, &c., 1919.

Crop.	Sown.	Pricked off.	Potted into 60's.	Potted into 32's.	Planted out in borders	Mulching.	First Top Dressing.	First Fruit Picking.	Last Fruit Picking.
Tomatoes (Isolation House) ...	Jan. 1	Jan. 12	Feb. 18	—	Mar. 31	May 27	June 12	June 11	Nov. 7
Tomatoes (Large Houses) ...	Jan. 2	Jan. 13	Feb. 19	—	Mar. 27-29	June 5-7	June 12	June 11	Nov. 25
Cucumbers in borders ...	Dec. 30, 1918.	Jan. 2	Jan. 5	Feb. 10	Feb. 27-28	—	Mar. 21	April 4	Sept. 15

The Glasshouse Tomato Moth and its Control.

L1. Lloyd.

The following account of the Glasshouse Tomato Moth, *Hadena oleracea*, and its control, is issued in its present form for the convenience of the Lea Valley Growers, to enable them to make their preparations for the coming year. The data upon which it is based will be published in full and distributed from the Experimental Station.

The Spread of the Pest.

The pest is spreading steadily and the means by which it spreads are clear. Many species of flying insects blunder into the glasshouses in their flight and are trapped there, as they are unable to discover the ways of escape. For instance the common Cabbage White Butterfly, *Pieris brassicae*, is frequently seen in them, beating itself against the glass and endeavouring to escape. At night certain species of common moths will occasionally be seen similarly trying to get out. Now the more numerous an insect becomes in the neighbourhood of a nursery the more liable is it to blunder in; while, should it become excessively common, the entry of a few each year will become a certainty. This is what has happened in the case of the moth under consideration.

From observations which have been made it appears to be the endeavour of many of the moths which emerge from the chrysalides in the houses to escape, and they may be seen at dusk beating against the glass and even working along the cracks where fresh air flows in and trying to force themselves through. Many thus escape from the houses and commence breeding in the neighbourhood of the infested nurseries. This causes an abnormal condition since, instead of the ordinary state of affairs when the moths fly in June and July with an occasional partial second brood in the Autumn, there is an artificial condition caused, in which the moths fly and breed on weeds and garden plants throughout the warmer part of the year, probably from April to October in favourable years. Thus in the immediate neighbourhood of the infested nursery the moths become unusually numerous, and where the nurseries are congested, the passage of the insect from one to the other is a simple matter. This is what has happened, for instance, among the crowded nurseries from Enfield Highway to Cheshunt.

A circular questioning the Growers about the history of the pest in their particular nurseries elicited information which confirms this view. The replies proved conclusively that it is not the normal habit of this moth, which is generally distributed and common, deliberately to enter glasshouses and to breed upon tomatoes. Had this been the case every nursery should have become infested shortly after its institution,

whereas the fact is that many nurseries in the Lea Valley have remained unattacked for more than twenty years, and have only commenced to suffer from the pest as it has crept into their locality. This steady spread does not account entirely for the present distribution of the trouble, and there are two other ways in which it may be introduced.

Firstly, seedlings carrying the eggs of the moth or young caterpillars may be purchased from infested nurseries. In this case the pest would start with a rush and its first year of occurrence would probably be a bad one. This has undoubtedly happened in some cases. Secondly, the moth may be introduced in the form of chrysalides in strikes returned from the market. The dry basket-work is very attractive to the caterpillar when it is ready to change; and where the strikes are left in infested houses overnight large numbers find their way into them and a proportion will pass through the markets undisturbed. It will occasionally happen that when the moths emerge the strike containing them will have found its way to another district, or even to another country. These two modes of spread will account for the sudden jumps which the pest exhibits in its distribution: e.g., its occurrence in Denmark (on the authority of Mr. Nielsen); its appearance at Harpenden in 1909, and in recent years at Worthing. However, it is not certain that the abnormal habit has developed in only one place.

Remedies.

In order to obtain thorough control over the pest the following precautions should be taken. (1) The caterpillars should be destroyed by spraying. (2) Caterpillars which appear when the plants cannot be sprayed should be trapped. (3) The moths should be trapped throughout the season, (4) Chrysalides should be destroyed. (5) Conditions favourable to the insect should be avoided when possible. These will be discussed in turn.

1.—Spraying.

Early spraying with arsenate of lead is the most essential part of the control. Every Grower who decides to rely upon hand-picking will sooner or later have a really bad year when he will bitterly regret not having followed advice. Several have done so this year. Hand-picking is a clumsy and inefficient method and the most expensive one that could be devised. Those Growers who have used the arsenate of lead in a thorough manner have learnt that by this means they can keep control till about the end of June, and that then a few caterpillars are seen fully fed, while by September they may be collected by the pint. This is accounted for by the following facts. The first flight of moths of the year commences to emerge in February in a block which is heated up in January and continues to do so until the beginning of June, and possi-

bly later, with the maximum flight about the end of April. The period of their emergence from the chrysalides is so prolonged for several reasons. One is that they are situated in different positions, and some are almost at the temperature of the outside air. Another reason is that even when a batch of caterpillars all turn into chrysalides at the same time, and these are all kept under the same conditions of temperature, the moths do not all emerge together. Some remain in the chrysalis stage as many months as the others do weeks. In the tomato houses, especially those heated up in March to receive the first plants which are planted out, moths will be still emerging when it is too late to spray with arsenate of lead, and the caterpillars will commence feeding when there is much unsprayed new growth on the plants.

It is a mistake to delay spraying until the caterpillars are seen feeding, as they may appear just after it is too late to do so. The paste should be used at the rate of two ounces in two gallons of water, or six pounds in a hundred gallons. Before the paste is added, saponin should be mixed with the water at the rate of a small half-teaspoonful in two gallons, or two ounces in a hundred gallons. This substance holds the arsenate in suspension during the spraying and forms an even film over the leaves. If this, or some substance with similar properties, is not used the spray is distributed unevenly, sometimes wastefully strong and sometimes much too weak. The paste will mix more readily if the requisite amount is worked into a thin cream with a little of the saponin water before being added to the bulk in the sprayer. A knapsack sprayer is efficient with this mixture and it has been found that a man with one of these machines can keep pace with the planting over twenty-five acres of tomato plants.

If there is any sign of caterpillars feeding on plants in the propagating house they should be sprayed at once. They should always be sprayed just after planting out, and again about a month before the first fruit will be picked. The spraying should be from above and the plants should not be again watered until the day after the spraying. The operator should wear a piece of muslin over the face to prevent the spray getting into the eyes and nose.

Experimental work has been done with a spray which is not poisonous to man and which may be used with safety on older plants. Details will be published shortly. Spraying old tomato plants however will never be very economical or quite efficient as the growth is too dense for a thorough distribution to be obtained.

2.—Caterpillar Trapping.

If caterpillars are found on the plants late in the season in spite of these precautions or through their neglect, much benefit may be obtained by trapping them in sacks. The full-

fed caterpillars travel considerable distances in seeking suitable places in which to become chrysalides and canvas proves very attractive to them. Old sacks should be loosely folded and placed under the gutters on the pipes, or on the lower wires. Naturally the more sacks so used the better, but if they are scarce four or five to a house will trap hundreds of chrysalides a week in a moderately infested block. It is a long and tedious business to collect the chrysalides and caterpillars from the sacks by hand, and it will be found much more economical and thorough to collect them in a barrow and to dip them for half a minute into a cauldron of boiling water, and then to shake them. Not only will all the chrysalides be killed but also the wire-worm beetles and the vast swarms of woodlice which accumulate with them. The sacks must be collected and dipped every twenty-first day. It is a waste of time to do them more frequently, but if they are left in the houses longer moths will begin to emerge. Both for this and for the moth trapping it is an excellent plan to obtain a calendar and mark distinctly the dates upon which these traps will need attention and to hang it in some conspicuous place.

3.—Moth Trapping.

The trapping of the moths will be found to reduce greatly the infestation when spraying with lead arsenate is no longer possible. The moths are long-lived and can lay more than ten batches of eggs. As they are readily attracted to certain baits they may be caught soon after their emergence and the laying of most of these batches of eggs may be prevented. Experiment showed that many will enter a trap before depositing any eggs.

An experiment in wholesale moth trapping was carried out in a block of twelve two-hundred-foot houses. The block was heated and planted in March. The plants were not sprayed and no organised hand-picking was practised. The first generation of caterpillars was at its maximum about the last week in May. The second reached its maximum the third week in July. It was then the most heavily infested of the twelve blocks in the nursery. Experimental trappings with various baits had been commenced in June, and at the beginning of July three traps were exposed permanently in each house. Moths were then caught at the rate of eighty a night and the number steadily declined till the beginning of August when the third flight of moths of the year commenced and, in the third week of this month, they were caught at the rate of a hundred and seventy five a night. The third generation of caterpillars following on this flight, which would normally have reached its maximum early in September, was absolutely negligible from the point of view of damage done. In the second week of this month an examination of one of the end houses plant by plant yielded only six big caterpillars and ten small ones. In neighbouring

blocks at this time, even where some early spraying with lead arsenate had been done, caterpillars were being collected by the thousand. The benefit of wholesale trapping of the moth was thus amply proved.

The trapping was effected in two-pound fruit preserving jars, eight inches high, three inches in diameter and with a neck two inches across. In each of these about three ounces of the following mixture was placed:—thick brown treacle, one part; ale, two parts; sodium fluoride, one per cent. The treacle used was purchased at ninepence a pound retail. A thin black fluid with the odour of burnt sugar, sold under the name of treacle, at sixpence a pound was found to be less effective. It is probable that when the thick dark molasses is again procurable it will be equally effective with the better quality of treacle used. The beer should not be a waste material containing the débris of hops but should be clear and containing no solid matter. The sodium fluoride is added to prevent fermentation and the consequent growth of a scum on the surface of the fluid, and also to poison any moths which drink and flutter out of the jars. The most convenient way of preparing the mixture is to place the requisite quantities of treacle and beer in a vessel and to pour it into another vessel, and rapidly backwards and forwards, till it runs smoothly. It should then be distributed in the jars to a depth of an inch, or an inch and a half. Finally the sodium fluoride should be added separately to each jar as it dissolves very slowly. It is not at all a dangerous substance to handle, being in fact largely used as a food preservative. A jar containing three ounces of fluid requires the amount which can be picked up on a sixpence. The jars are then suspended from the wires near the gutters by short strings tied about their necks.

Six jars should be used in each two-hundred-foot house if possible. The minimum should be three to each house of these dimensions. At the end of four weeks the jars should be emptied and rebaited. If a large number of moths are being caught they should be scooped out, or the jar will fill up till the trap ceases to be effective. When the moths are removed they should be collected in a vessel and thrown outside the houses.

It is not essential that the jars should be as specified. Small ones may be used but it is desirable that they should be fairly deep in proportion to their width, that they should have a pronounced shoulder, and a mouth opening at least an inch and a half across. The traps should be used in the propagating houses and should be placed in each block as the heat is put into it, and should remain in use throughout the year. Used in this way they will trap a large number of moths which would otherwise pass outside and commence breeding there, not only damaging garden crops but also giving rise to that congested condition of this species of moth about the nursery, a danger which must be abolished.

It has been proved that the risk of drawing moths into the houses is negligible as will be shown later. At the same time it would be unwise to place a trap immediately below a broken pane.

The cost of this trapping, apart from the cost of the jars, will be about £2 an acre at the present price of materials, if sixty traps to an acre are used.

4.—Destruction of Chrysalides.

This is chiefly winter work.

The picking baskets need attention when the season is over as they harbour chrysalides. This is especially true of those lined with canvas. The practice has been to store these over the winter and to bring them into the houses without attention when the fruit picking begins. Moths then emerge from them and their offspring commence feeding on plants no longer protected by the early spraying. These baskets should therefore be dipped in boiling water, an operation which will destroy all the chrysalides. Special baskets and strikes should always be kept for picking and those from the market should never be allowed in the glasshouses. This applies not only to tomato growing but to all nursery work. There is little doubt but that "red spider," and possibly "white fly" also, may be introduced into a glasshouse with a market basket. Those used for picking should be painted or marked in some characteristic manner so that they may be kept for this purpose alone.

The canes should be tied in bundles and dipped for a few seconds in boiling water to destroy chrysalides which may be in them.

If possible the houses should be drenched with boiling water before the mulch is removed. Most of the chrysalides on the ground lie in or just below the mulch and if this is removed untreated some of them will become moths in the following summer. The mulch also contains many wire-worms and should not be spread on the fields untreated for this reason. If the soil is heavy and wet the chrysalides lie very superficially, but in light friable dry soil they may go to a greater depth. Whenever the soil comes close up to a pipe a spadeful should be dug out from below it and spread thinly over the mulch before the boiling water is used. The Grower should inspect his own infested houses and if he finds the chrysalides at a greater depth than an inch along the walls or around the piers a spadeful of earth should be removed and spread before the drenching. After this operation a number of chrysalides should be collected from a variety of positions in the ground and should be placed in a plant pot with some soft earth. After an interval of three or four weeks they should be broken open. If the contents are green and fresh they are still alive and the drenching should be repeated. If the contents are brown and corrupt, or dry, the insects are dead. It is not possible to tell immediately after

the brief immersion of the chrysalides in hot water whether they are dead or alive. Boiling water will be found more effective than carbolic acid for this pest.

Fowls or pigs would scratch up and eat a large number of chrysalides and may be allowed to run in the houses with advantage when the season is over.

All crevices and joints in the walls and woodwork should be examined from the ground to the ridge. It has been noted that the old nests of spiders frequently conceal chrysalides behind them. They are also often found spun up in the angles between the glass and the wood and are then somewhat inconspicuous. They are frequently hidden in the wooden ventilators in the walls, and as moths from these would be kept cool and emerge late in the Spring they should be especially looked for. The stonework should be pointed and lime-washed. It would be a good plan to pass the flame of a painter's blow-lamp into all crevices of the wood-work, especially about the gutter-boards.

5.—General Precautions.

In dealing with this, as with most other pests, it is of great importance that the nurseries should be kept orderly. Weeds should not be allowed to grow either inside, or in the neighbourhood of the houses. One reason for this is that the caterpillars can mature so much more quickly upon some of these than on tomato plants. Also when a man is spraying the plants he is very liable to miss the weeds. Those below the shelves in the propagating houses and stray seedlings should be especially looked for and removed. The border of weeds often allowed to grow around the bases of the walls outside should be constantly hoed up. Caterpillars may easily feed up on these and pass into the houses to become chrysalides.

Fallen broken fruit should never be allowed to lie about in the houses. The moths cannot feed on unbroken fruit but do so eagerly when the skin is ruptured and they can get at the juice. Under experimental conditions moths fed on this diet lived twice as long and laid three times as many eggs as those which were given no food. This can be guarded against with very little trouble.

Prospects.

There is good reason to suppose that this pest is a special race of the common moth partially adapted to a life in green-houses on a tomato diet. The fact that its spread can be largely traced points to this conclusion, and the experience gained by experimental breeding yields further evidence. Ordinarily the caterpillars feed on a wide variety of low plants and it has been proved that tomato foliage is a less suitable food for them than such common weeds as *Chenopodium* (Fat hen) and *Polygonum* (Knotgrass). There is no difficulty in rearing them from the eggs on these, whereas on tomato plants the

growth of the caterpillar is always slower and the large majority die if confined to this diet alone. It is for this reason that the caterpillars cease feeding on the foliage and, in their search for a change of food, attack the fruit and bite into the stems and eat along the pith. It is for this reason also that the tomato industry of the Lea Valley has not been entirely ruined by this very prolific moth, one of which is capable of laying 900 eggs. If all survived the offspring of a single pair starting life in April could be in the second generation in August half a million caterpillars; that is, thirty to every plant over an acre. This point will be discussed more fully later.

In nature the insect is kept in check by various factors, such as unfavourable weather and the attacks of insectivorous animals and parasites. In the greenhouse the weather is favourable to it throughout the growing season, and the enemies of the insect are relatively few. Those that find the tomato diet suitable are therefore fostered by the artificial conditions, and in the rapidly succeeding generations they may be expected to form a rapidly increasing proportion.

It has been shown above that the early spraying with arsenate of lead can never do more than partly check the pest. Unless other precautions are taken and the insect is abolished from the greenhouses before its adaption has become perfect, its ravages must be regarded as a perpetual annual tax on the tomato industry of £5—£10 an acre, or even more. There is also the danger that, as the offspring of the early emerging moths are annually destroyed, the tendency towards late emergence will be further developed, and the spraying with lead arsenate would then become ineffectual. It will therefore be well worth while for the Growers to combine in an attempt to eradicate the pest entirely and thus avoid this annual waste of money. While it is still in some respects weak a united effort may exterminate it. Half-hearted methods aimed simply at bringing the annual loss within reasonable bounds will never succeed, but it may possibly be done in a few years by the slight additional cost of trapping the moths, an expenditure that will in any case be amply repaid each year. It is not an alternative to the spraying but an additional remedy, and all Growers who have the insect in their nurseries are strongly urged to adopt it until the pest has been stamped out.

Apparatus and Material Required.

A spraying machine; knapsack or other type.

A small open boiler for dipping baskets and sacks.

Outfit for hot water drenching.

60 jars for each acre of tomatoes; and for each acre:—

Arsenate of Lead Paste 20 lbs.

Saponin 6 ozs. Thick Treacle 30 lbs.

Ale 48 pints. Sodium fluoride 1 lb.